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THREE NEW PRINCIPLES OF FOOD PROCESSING

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Production of frozen fruits and vegetables in the United States now accounts to almost 900 million pounds a year. The frozen-foods industry has quadrupled its output in the last dozen years and is still expanding rapidly. Consumers in the United States have eagerly sought frozen foods and willingly paid higher prices for them than for many canned or fresh products because of their high quality and convenience of use.

Considerable effort has been devoted to reducing the high cost of producing, transporting, and storing frozen food products. During the last few years a new type of product has come on the market, offering a partial solution to the cost problem as it affects the manufacture and distribution of frozen fruit juices. This product is frozen concentrated orange juice, which has had a truly remarkable success in the United States. Its production began just five years ago and now frozen concentrated orange juice provides an outlet for something like 20 percent of the U. S. orange crop. The new concentrate has turned back a threatened orange surplus, and there is evidence that it has even contributed to an increase in orange-grove real estate values in certain areas. The method used in its production is being extended to the production of concentrated juices from other fruits, including grapes, grapefruit, and apples.

A public-service patent on this process is assigned to the Secretary of Agriculture of the United States for free licensing to producing firms. Public ownership of this patent has no doubt contributed effectively to the phenomenal growth of the orange-concentrate industry during the past few years.

In making frozen concentrated orange juice, the fresh juice is first concentrated by high-vacuum, low-temperature evaporation to approximately 1/5 its original volume, thus increasing the solids content from about 12 percent to 58 percent. The resulting concentrate is then "cut back", or diluted, by adding an amount of fresh, single-strength juice equal to about half the volume of the concentrate, which reduces the solids content of the final product to 42 percent. Much of the product's flavor comes from the added fresh juice. The concentrate is quickly chilled to a slush, filled into cans, and frozen at -18 degree Centigrade (0°F.) or lower. It must be kept at this temperature during transportation and

storage. Known as a "4-to-1" concentrate, the product is reconstituted before serving by adding 3 parts water to one part frozen concentrate.

Consumers like this orange-juice product because it has excellent flavor, closely approaching that of fresh juice, and is convenient to use. It also resembles fresh juice in appearance. From the processors' and distributors' standpoint, however, the product's chief advantage is that its concentrated form permits it to be shipped and stored economically at the required low temperature. The principle of concentration is a new and important one for the frozen-food industry. It offers particular promise to fruit growers in areas far from major markets, because it will enable them to reduce their shipping costs and thus compete on more even terms with producers located nearer the large centers of population.

Another development in the field of concentrated food products involving another new principle of food preservation, is the production of volatile fruit essences and concentrated juices flavored with them. It is fairly simple, of course, to concentrate fruit juices by evaporation to a fraction of their original bulk, but during the process you lose the volatile flavor constituents that make the juices appetizing and give them their distinctive taste. The problem is to recover these elusive substances, so that they can later be returned to the juice, or to other processed fruit products, to restore their natural flavor. The Department of Agriculture has developed equipment and methods for accomplishing this, and a large number of companies are now engaged in commercial production of volatile flavor essences from various fruits.

The Department's Eastern Regional Research Laboratory worked out a commercially feasible process for recovering the volatile flavors of apple juice in concentrated form for the first time in 1944. From that process have stemmed developments that should have a strong impact on the fruit-processing industry and result in products of enhanced flavor.

The initial aim of the apple-essence work was to recover completely the volatile apple flavors and to concentrate them so they could be reincorporated into a concentrated juice without diluting it below 70 degrees Brix. This goal was achieved and a truly full-flavored concentrated apple juice was obtained.

It was apparent that this work had broader implications. We found that with slight modifications of equipment and method the essence-recovery process could be applied to the juices of many fruits -- grapes, strawberries, blackberries, peaches, and others. The essences possess the characteristic bouquet of the fresh fruit and can be used to restore the aroma and flavor to processed fruit products such as jams, jellies, and preserves, which normally lose some of their natural fruit flavor during cooking. The essences also give genuine fruit flavor to carbonated beverages, candies, ice cream, ices, and other food products. Their potentialities for enhancing the flavor of canned fruits and single-strength fruit juices have not yet been explored but would certainly appear to have promise.

Fruit essences should also play an important part in the rapidly expanding field of frozen concentrates. At present, as I mentioned, the fresh flavor of frozen concentrated fruit juices is normally contributed by the fresh, unpasteurized juice added to the first high-Brix concentrate. But the final product, although of good flavor, actually contains less than the full quota of volatile constituents present in the original juice. We have recently made an excellent frozen concentrated apple juice, having all the flavor of fresh juice, by adding the complete essence recovered from the juice to a concentrate of 45 degrees Brix. It was not necessary to add any fresh juice. The same procedure can be used with frozen concentrated juices from Concord grapes and possibly from other fruits as well.

Now that fresh, natural flavor and aroma can be obtained through essence recovery, the question arises as to whether it is necessary to make frozen juice concentrates, which must be stored at sub-zero temperatures. We are currently investigating the possibilities of concentrated apple and Concord grape juice containing essence and having a Brix sufficiently high to make them self-preserving without the need for preservation by freezing. It appears that storage of such products at about 1.5 degrees C. (35°F.) may be adequate.

The third new principle of food processing I should like to discuss very briefly is the use of antibiotics in preserving foods. Although still in its preliminary stages, this development could have very wide application and bring about important changes in food-processing techniques.

As you know, the almost miraculous success of penicillin gave great impetus throughout the world to the study of antibiotics. Thousands of sources have been combed and hundreds of laboratories have been involved in research to find new substances of this type which may have medical value. But in spite of all this work, very little attention was paid to the possibility of using antibiotics in the preservation of foods.

Several years ago studies in this field were begun by the Department's Western Regional Research Laboratory. In preliminary screening tests, using a number of available antibiotics against common food-contaminating organisms, we found that subtilin -- an antibiotic first isolated and studied at the Western Laboratory -- had particular promise. Further work showed, in brief, that vegetables to which subtilin had been added in concentrations of 10 to 20 parts per million, and which were then heated to the boiling point of water and held at that temperature for 10 to 20 minutes, were effectively preserved. Vegetables canned in this way have survived for long periods in storage without evidence of microbial spoilage.

The implications of these findings were clear. The subtilin treatment makes it possible to use much lower cooking temperatures for a shorter length of time than is the case in ordinary canning. Its advantages from the standpoint of better quality and flavor of the canned product have been apparent in the trials made to date. Cut corn canned in this way can hardly be distinguished from corn obtained directly from the field.

Our taste panels have been unable to distinguish between corn that has been canned with subtilin and held for months at room temperature, and corn from the same batch which was blanched, frozen, and held at -23°C . (-10°F .) for an equal storage period.

Besides the improvement in taste quality made possible by the milder cooking required, there is also the important possibility that antibiotic treatment can be used to preserve products not now available in canned form. For example, broccoli, cauliflower, and brussels sprouts are not often canned because the cooking required causes packs of these winter vegetables to be mushy. Using the milder heat treatment that is sufficient for subtilin packs, excellent canned products from these vegetables have been obtained.

The Western Laboratory has done preliminary work on a number of products canned with subtilin, including peas, asparagus, corn, fresh milk, evaporated milk, fish, chicken, celery, mushrooms, and precooked rice. With only one or two exceptions the packs have been adequately preserved and most of them were of better quality than similar materials cooked under regular canning schedules.

When subtilin was first discovered, we thought it might be valuable in medicine, but no promising possibility was uncovered for its use in this field. The antibiotic, produced by the common bacterium Bacillus subtilis, was found to be a polypeptide containing several of the ordinary amino acids, including some with dextro as well as levo rotation. It also contains lanthionine, a sulfur amino acid, here shown for the first time to occur in a natural product. One or more other sulfur amino acids of unknown character are also present.

Fortunately for its potential use in food preservation, and unlike any other known antibiotic, subtilin is at least partly digested by proteolytic enzymes. This fact has been demonstrated both with trypsin and pepsin. For this reason alone it appears extremely unlikely that ingesting small amounts of subtilin over long periods will be dangerous to health. This consideration has of course been in our minds from the beginning of our investigations.

We have fed a hundred parts per million of subtilin in rat diets over periods of months without observing the slightest sign of harmful effects. Larger amounts, given in one dose, have likewise been quite innocuous. In treating hospital patients with subtilin to determine whether the antibiotic had any usefulness in medicine, we found that it produced no adverse reactions when administered orally. In other words, we have discovered no reason for thinking that subtilin would have any effect, good or bad, on the health of consumers if it were incorporated as a preservative in foods. The matter is still open for investigation and discussion, of course, and we realize that every avenue of approach must be pursued until we are absolutely sure that no harm can result from the use of this antibiotic in food products.

The possible economic advantages of using subtilin in the canning process are worth considering. First, of course, there is the possibility that the enhanced flavor and better texture of foods that have been subjected only to mild cooking will increase the sale of those items, possibly at premium prices. Second, the cost of the heat-processing step in canning plants would be reduced through replacement of the present relatively long cooking under high steam pressure by a process of much shorter heating at or near atmospheric pressure.

The cost of the subtilin itself cannot as yet be predicted with certainty, since it has been produced so far only on a pilot-plant scale. However, on the basis of our present information, it would appear that the cost will be no more than ~~1/10~~ of a cent for each No. 2 can of produce (about half a liter). It should be pointed out that 20 parts per million of subtilin corresponds to about 18 grams of the antibiotic (less than 1 ounce) per ton of canned produce. 1/10

The work at the Western Regional Research Laboratory is only the beginning of the investigations that must be made on this process. It is certainly conceivable that we may find a combination of antibiotics that can be added to fresh foods to prevent the growth of microorganisms without heat treatment. This would be an ideal situation, provided that the mixture of antibiotics had no adverse physiological effects. Our studies of this and related problems are continuing. We are cooperating with a number of food-manufacturing companies and other research organizations in further experiments, because we realize that the field is so broad and so much additional work must be done that we cannot hope to cover more than a small area of it ourselves.

It seems reasonable to expect that within the next several years, as a result of developments such as those I have described, we may witness far-reaching changes in food-processing techniques.

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